CALIFORNIA
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A ROADMAP FOR PIER RESEARCH ON BIOLOGICAL ISSUES OF SITING AND MANAGING TRANSMISSION LINE RIGHTS-OF-WAY

STAFF REPORT

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Executive Summary

California's population growth of approximately 600,000 people per year is increasing pressure on the State's resources, including its natural diversity and energy supplies. California's economy is dependent on a reliable and stable electricity supply, which requires adequate transmission systems; however, the transmission sector needs to upgrade existing older systems and add new infrastructure to maintain pace with the rising electricity demand. In addition, new transmission lines will likely be required to meet the target of the Renewable Portfolio Standard (SB 1078), which is designed to increase the proportion of the State's retail electricity sales produced by renewable resources from about 11% currently to 20% by 2017.

Transmission line right-of-way (ROW) corridors through terrestrial landscapes are managed so that vegetation does not interfere with conductors and disrupt the ultimate management goal of providing safe and reliable transmission of electricity. This management can result in the three greatest contributors to species decline: habitat loss, fragmentation, and the growth of invasive species. With about 40,000 miles of transmission line in California, ROWs represent a prominent feature on the landscape; yet little is known abut the ecological consequences or conservation potential of this disturbance. Because these linear corridors are often quite long, several habitat types and species of concern may be involved, and siting new lines is often complicated and lengthy. The siting process is also subject to public opposition due to biological, visual, real estate value, and health concerns. Strategies that identify opportunities to promote conservation within ROWs while maintaining system reliability could contribute to statewide conservation efforts, reduce negative public perception, and facilitate the siting of new, much-needed transmission lines.

The PIER Environmental Area (PIER-EA) has identified four areas of research on the biological issues of siting and managing transmission line ROWs that will help minimize the impact of power line corridors on California's natural biota, while helping to ensure the delivery of safe, reliable, and affordable electricity. First, researchers need to identify conservation risk and opportunities, so that stakeholders can develop and implement informed ROW management strategies as the State's transmission system grows and ages. Second, there is a need to identify and assess ROW management alternatives, focusing on the options that best protect the State's biota while providing effective, economical management. Third, efforts are needed to develop tools and methods to facilitate environmental assessments for ROW sites, so that environmental issues can be identified more quickly and appropriate transmission upgrades can proceed with minimal delay. Last, it is essential to identify means to disseminate information about ROW management in California, to bolster understanding and collaboration among all stakeholders.

The successful completion of the activities outlined in the roadmap will help ensure that California's transmission system can deliver sufficient electricity to meet the State's needs while minimizing the impact of ROW management on the State's flora and fauna. A statewide, comprehensive conservation strategy that included transmission line ROW corridors would enable decision makers and transmission line operators to recognize resource management opportunities on existing lines and make proactive decisions

regarding future developments. Environmentally responsible stewardship could help protect and restore sensitive areas or species at risk, contribute to more regional protection efforts, and possibly reduce negative public perception of ROW management. Better understanding of where development will result in fewer impacts could reduce the time required for siting.

The products from this research will be able to be used by utility companies, natural resource managers, policy makers, and researchers to identify optimal land management and conservation strategies associated with ROWs.

In the short term, this roadmap recommends that PIER-EA funds be made available to address the following objectives:

Objective	**Projected Cost ($000)**
• Identify Conservation Risk and Opportunities	500*
• Identify and Assess ROW Management Alternatives	3,000*
• Develop Tools and Methods to Facilitate Environmental Assessment of Sites	3,000*
• Identify Means to Disseminate Information	500
Total Short-term Cost	**7,000**

Note: An asterisk (*) indicates a high probability that the work will be leveraged with other ongoing efforts. The figure given is the California Energy Commission's projected expenditure to complete the short-term work.

Roadmap Organization

This roadmap is intended to communicate to a broad audience with varying levels of knowledge about the issue. The sections build upon each other to provide a framework and justification for the proposed research and development—both for stakeholders well-versed in the biological issues of siting and managing transmission line right-of-ways, as well as for those new to the issues.

Section 1 states the issue to be addressed. *Section 2: Public Interest Vision* provides an overview of research needs in this area and how PIER plans to address those needs. *Section 3: Background* establishes the context of PIER's right-of-way work. *Section 4: Current Research and Research Needs* surveys current projects in this area and identifies specific research needs that are not already being addressed by those projects. *Section 5: Goals* outlines proposed PIER-EA activities that will meet those needs. *Section 6: Leveraging R&D Investments* identifies methods and opportunities to help ensure that the investment of research funds will achieve the greatest public benefits. *Section 7: Areas Not Addressed by this Roadmap* identifies areas related to right-of-way research that the proposed activities do not address. *Appendix A: Federal and State Laws That Apply to Transmission Line ROWs* offers an overview of laws that affect ROW issues. *Appendix B: Vegetation Types within 2 Kilometers of Transmission Line Corridors* lists the vegetation most likely to grow near ROW corridors in California.

1. Issue Statement

It is in the public interest to improve California's quality of life by minimizing the impact of power line corridors on the integrity of California's natural ecosystems and biotic diversity while providing sound, safe, reliable, and affordable energy services and products.

2. Public Interest Vision

The primary mission of the California Energy Commission's Public Interest Energy Research (PIER) program is to conduct research that helps deliver "…environmentally sound, safe, reliable, and affordable electricity…" to California citizens. The mission of the PIER Environmental Area (PIER-EA) is "…to develop cost-effective approaches to evaluating and resolving environmental effects of energy production, delivery, and use in California, and explore how new electricity applications and products can solve environmental problems." This roadmap explores research options that maximize conservation opportunities along transmission line right-of-way corridors while providing reliable electricity delivery. It focuses on terrestrial biodiversity.

California, which is considered to have exceptional levels of biodiversity and the highest number of endemic species of any state in the nation, has a population growth of approximately 600,000 people per year. This growth is causing increasing pressure on the State's resources, including its natural diversity and energy supplies. California's economy is dependent on a reliable and stable electricity supply, which requires adequate transmission systems. The transmission sector is currently faced with significant challenges because of a need to upgrade existing older systems and add new infrastructure to keep up with the rising electricity demand. In addition, new transmission lines will likely be required to meet the target of the Renewable Portfolio Standard (SB 1078), which is designed to increase the proportion of the State's retail electricity sales produced by renewable resources from about 11% currently to 20% by 2017.

Transmission line right-of-way (ROW) corridors are managed to keep vegetation from interfering with conductors. This disturbance on the landscape can result in habitat loss (or alteration) or fragmentation—the two greatest threats contributing to species decline. In addition, the disturbance of these corridors from maintenance activities facilitates the invasion of exotic species—now regarded as the third leading threat to imperiled species, behind habitat destruction. Natural vegetation in ROW corridors through low-stature habitats is bladed during construction, but generally left intact after construction; therefore, these corridors often have a temporary effect on the landscape. Natural vegetation in ROW corridors that traverse habitats that have been modified by activities such as agriculture or urban developments can offer refuges of natural (albeit fragmented) habitat. However, often the corridors remain occupied by the land use activity (such as agriculture) that occurred prior to the transmission line construction.

Although permitting authorities follow mandates designed to ensure system upgrades, or to ensure that new developments are sited in an environmentally responsible manner, a lack of readily available information hampers analyses. The public is often opposed to building new transmission in neighborhoods because of concerns about real

estate values, health, and visual aesthetics. As a result, time frames from planning to actually building a new transmission line can be five years, and no new major lines have been constructed in California since the mid-1980s.

To ensure that California's transmission system can be maintained and grow to meet the needs of its citizens while limiting the impact on the State's biological resources, research and development is needed in four areas: First, researchers need to identify conservation risk and opportunities, so that stakeholders can develop and implement informed ROW management strategies as the State's transmission system grows and ages. Second, there is a need to identify and assess ROW management alternatives, focusing on the options that best protect the State's biota while providing effective, economical ROW management. Third, efforts are needed to develop tools and methods to facilitate environmental assessments for ROW sites, so that environmental issues can be identified more quickly and appropriate transmission upgrades can proceed with minimal delay. Last, it is essential to identify means to disseminate information about ROW management in California, to bolster understanding and collaboration among all stakeholders.

The successful completion of the activities outlined in Section 5 (Goals) will help ensure that California's transmission system can deliver sufficient electricity to meet the State's needs while minimizing the impact of ROW management on the State's flora and fauna. A statewide, comprehensive conservation strategy that included transmission line ROW corridors would enable decision makers and transmission line operators to recognize resource management opportunities on existing lines and make proactive decisions regarding future developments. Environmentally responsible stewardship could help protect and restore sensitive areas or add to the recovery of species at risk, contribute to more regional protection efforts, and possibly reduce negative public perception of ROW management. Better understanding of where development will result in fewer impacts could reduce the time required for siting.

The products from this research will be able to be used by utility companies, natural resource managers, policy makers, and researchers to identify the optimal land management practices and help to design conservation strategies.

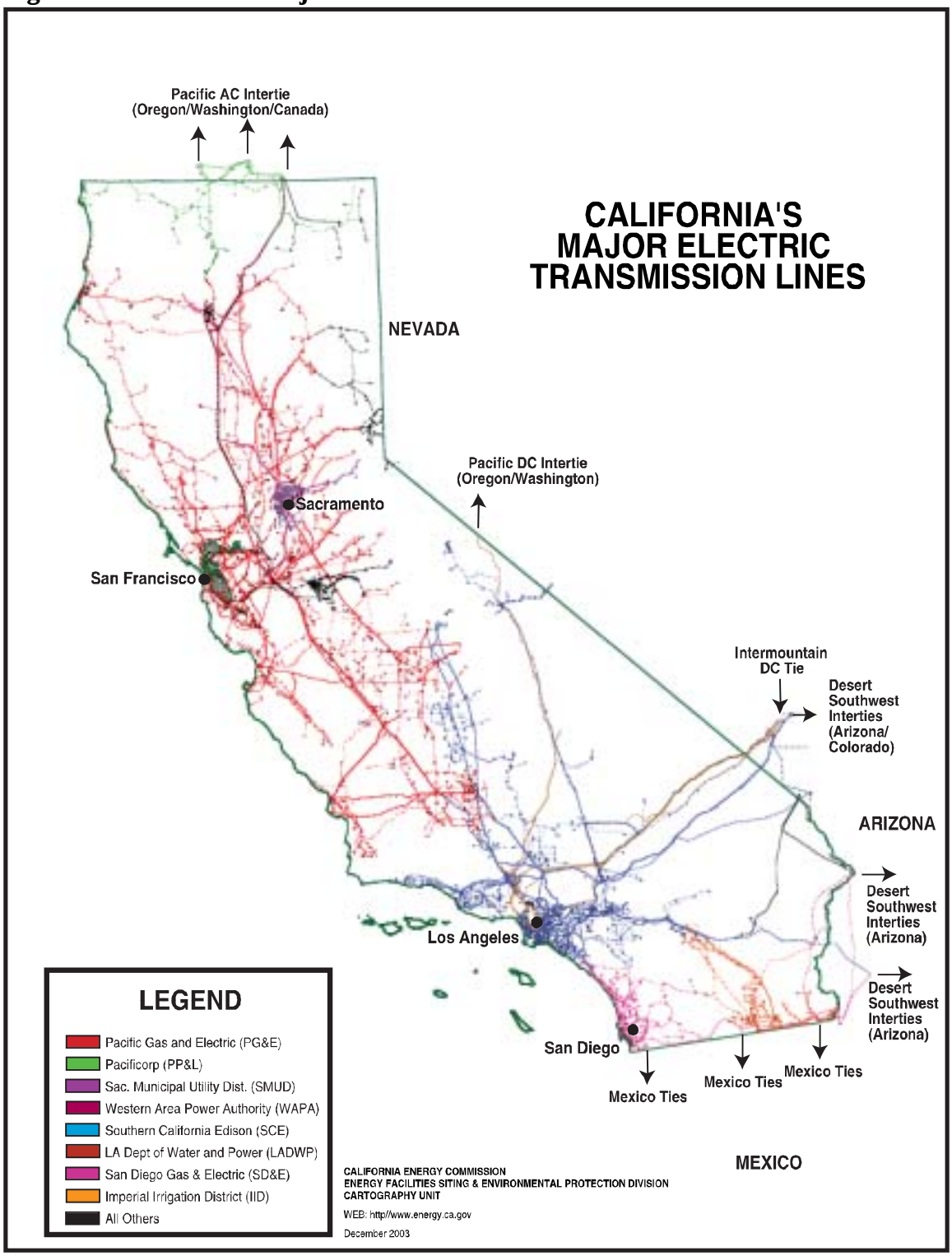
3. Background

Power lines are a critical infrastructure of California's energy system and a seemingly ubiquitous part of the landscape. Right-of-way corridors associated with transmission lines are normally between 150 to 300 feet wide. They are managed to prevent tall-growing trees and other vegetation that could interact with conductors and interfere with the ultimate management goal of providing safe and reliable transmission of electricity. With about 40,000 miles of transmission line in California (Figure 1), ROWs represent a prominent and expanding infrastructure on the landscape; yet, little is known about the ecological consequences or conservation potential of this disturbance in the State. Developing a management strategy that identifies opportunities to promote conservation within ROWs while maintaining system reliability could contribute to statewide biodiversity preservation efforts and reduce negative public perception of transmission line ROWs.

The importance of non-ROW habitat corridors as a conservation element that connects otherwise isolated patches of similar habitat has been widely studied. Corridors associated with transmission line ROWs are quite long and may represent a dramatic departure from adjacent habitats, and therefore, are not normally regarded as conservation elements. In fact, ROWs that contain habitat divergent from the surrounding landscapes contribute to habitat loss or fragmentation, while the disturbed nature of ROWs facilitate invasions by exotic species. These effects are the three most significant threats to species endangerment and vulnerability. Conversely, ROWs that maintain habitat assemblages can be managed to support sensitive species that are dependent on low-stature habitats, facilitate protection of critical habitat features (e.g., nesting), serve as a fire break, or provide habitat islands in developed regions.

The effects of the ROW on biota are species dependent. Some species are more tolerant to highly modified, fragmented, or edge habitats; whereas, others are sensitive or interior species that experience population reductions or local extinctions in these habitats. Most research has concentrated on effects to birds and mammals, and very little is known about effects to amphibians, reptiles, and invertebrates. Species' reactions depend on the width of the ROW, the composition of its vegetation, and the abruptness of the transition from adjacent habitat types (i.e., the *edge effect*). Maintenance activities can affect the phenology and stability of the vegetation which influences seasonal and successional use by birds and mammals (Gates 1991; Anderson

Figure 1. California's Major Electric Transmission Lines



et al. 1977). Species attracted to, or tolerant of, modified ROW corridors may out-compete, be predatory or parasitic, or otherwise cause deleterious pressure to sensitive species. In general, habitat specialists that are often harmed by habitat loss and degradation and by population isolation are of greater concern, while habitat generalists tend to adjust to various pressures.

The potential for ROWs to adversely affect ecosystem integrity and function is highest when vegetative characteristics within the corridor greatly depart from that of the adjacent habitat. For forest-dwelling, interior species, ROWs can act as barriers, and avoidance may extend to distances of as much as 330 feet from the ROW (Chasko and Gates 1992; Graham 2002). The degree of impact from the ROW corridor itself largely depends on the degree of fragmentation from all impacts on the landscape. Fragmentation creates a greater proportion of edge habitat, which attracts edge species (e.g., raccoons and deer) and may, in fact, increase species richness. The species present in a ROW, however, may not be similar to those in the habitat the ROW dissects, and increasing diversity is not a desirable objective if the outcome also results in declines of rare species dependent on large areas of habitat. Corridors with shrubs will attract shrub-dependent species and those with grasses will attract grassland-dependent species. ROWs with mowed grass have been shown to cause a higher incidence of nest parasitism by brown-headed cowbirds, and edges tend to provide increased opportunities for nest predation (Rich et al. 1994; Graham 2002). Two studies conducted in the same ROW through a pine and hardwood forest in Tennessee found that replacing the overstory with low-growing vegetation reduced forest height diversity but increased cover and density of low-growing vegetation, which decreased bird species richness, but increased small mammal species richness (Kroodsma 1976; Johnson et al. 1979). The impact of a particular ROW must be evaluated on a site-specific and species-specific basis.

The degree of impact that a ROW has on a landscape also depends on corridor width. Gaps of 250 feet or more created by power lines in southwestern U.S. forests negatively affected forest songbird population dynamics (Graham 2002). Abundance of forest interior neotropical migrant birds—a group of species of conservation concern because of population reductions—declined in corridors 50–75 feet wide but not in corridors 25 feet wide (Rich et al. 1989). In a deciduous forest in Tennessee, narrow (39-foot) corridors had reduced bird diversity more than wider corridors but provided the least change in species assemblage from the surrounding habitat (Anderson et al. 1977). In this study, wider corridors contained edge and grassland, rather than forest, species. Increased patchiness of shrub vegetation within a power line corridor had greater fledging success than homogeneous habitats (Chasko and Gates 1992). In an eastern U.S. deciduous forest of oak and pine stands, Schreiber and Graves (1977) found that small mammals crossed ROW widths of 160 and 340 feet that contained shrubs, grasses, and well-established ground cover.

The recent trend in power line right-of-way management is to practice integrated vegetation management (IVM) (McLoughlin 2002; EPRI 2002). IVM incorporates mechanical, chemical, and biological methods for vegetation management and is embraced by many eastern utilities. Mechanical and chemical treatments are used to control tall-growing vegetation and encourage a low-stature community. This low-growing community acts as the biological control to prevent the regeneration of trees by

reducing sunlight and available area. IVM depends heavily on herbicide treatments, a practice not widely accepted by the general public. The theory behind IVM is that as more chemical treatments are applied to reduce tall-growing vegetation, the abundance of tall-growing species is reduced and that of low-stature species increases. Therefore, the treatment performed becomes more selective, reducing the amount of chemicals applied during successive treatments. The result is a biologically controlled habitat with minimal chemical and mechanical treatments needed over time, which translates to reduced maintenance costs. Even though the ROW will still require regular treatments to prevent natural succession to tree-dominated landscapes, this regimen is greatly preferable to denuded ROWs, because the vegetated landscape protects soil and water quality values, is more aesthetically pleasing, and can support some diversity of shrub species. However, a departure from the composition of adjacent, natural habitats can result in species assemblages different from those in the surrounding habitats, as well as the other related effects described earlier. To determine the overall benefit of the treatment, the composition of the faunal assemblage created must be compared to the desired effect.

Using IVM and/or other treatments that strive to create habitat has conservation value. Shrub and grassland species with small home ranges (e.g., small mammals) or highly specific habitat requirements (e.g., butterflies) could be managed beneficially in ROW corridors. In forested habitats, the nature of the corridor edge determines how strongly that edge acts as a boundary to wildlife habitat and movement. Therefore, creating a series of successional vegetation bands parallel to the edge can minimize the effects found at abrupt edges and reduce the barrier effect (Gates 1991). This treatment can result in enough vertical and horizontal structural and shrub species diversity to provide food and cover to attract a variety of birds (Meehan and Haas 1997; Chasko and Gates 1992). Treatments to encourage diversity should include components to eradicate invasive exotic species, because the disturbed ROWs may facilitate the spread of exotic species. The impact of invasive exotics on biodiversity is significant—about 42% of all species listed under the federal Endangered Species Act are at risk because of competition with or predation by exotic species. Invasive species encroach into parks, preserves, refuges, urban areas, and agricultural lands. Costs to the U.S. economy are in the hundreds of billions of dollars annually for eradication, lost production, or fatalities. (Pimentel et al. 1999).

Transmission line towers along ROWs can provide suitable nesting, roosting, and foraging sites for raptors and ravens. Stahlecker (1978) and Craig (1978) noted that raptors used these towers more than natural perches in areas of Colorado and Idaho. Red-tailed hawks and ravens used transmission towers in the Mojave Desert more than expected, particularly in relation to trees (Knight and Kawashima 1993). Dramatic increases in raven populations in the Mojave and Colorado Deserts are a concern because predation is resulting in reduced survival rates of the desert tortoise, a federally and state-threatened species (Boarman 2002). Increases in the number of ROWs in the Lokern Natural Area in Kern County appears to be facilitating use by the invasive European starling (Cypher pers. comm. 2003).

Wildlife agencies have expressed concern that additional transmission lines could induce growth into new areas, which could in turn affect habitat that supports protected species. However, construction of transmission lines generally follows a need

in additional capacity to support expected or accommodate existing growth (National Economic Research Associates 2002). Under state statutes, electricity providers have an obligation to serve new and existing customers with sufficient, reliable energy. Therefore, growth dictates the need for additional electricity, rather than the reverse. Additionally, transportation of electricity is not linked to specific localities per se; it is distributed across the transmission grid and flows to an area of need at a given moment. Given the network of the transmission line grid, this area could be throughout the western United States or Mexico. Electricity generated at a particular site could ultimately be delivered for use several hundred miles from the source. The transmission line itself is the electron highway and a line running through a particular neighborhood could be supplying electricity to anywhere on the grid.

3.1 The California Perspective

There is a paucity of research conducted on biological diversity enhancements and ROW management in California. Published research on habitat management in transmission line ROWs is not abundant in general, and most is focused on areas outside of California. Many of California's utility operators are either not aggressively pursuing this type of research and development or are reluctant to share this information with the public because of potential legal repercussions. It is important to recognize that many transmission operators perceive that managing the ROWs for listed species may in fact result in violations of laws during emergency or routine operation and maintenance practices. Thus, to encourage the utilities to adopt a program that enhances listed species, measures must be incorporated to protect them from legal repercussions (such as the Fish and Wildlife Service's Safe Harbor Program) .

California is the most biologically diverse state in the nation. The State is also the most populated, and estimates indicate that population growth will continue to increase pressure on State resources. Wise and strategic resource planning is paramount to protecting our resources while providing the necessary infrastructure to meet our growing demands. ROWs of all types—roadways, pipelines, and transmission systems—seem relatively benign in the overall scheme, but become increasingly important as more habitat is lost, degraded, or fragmented by development.

The impacts of ROW corridors on biological resources have only recently been addressed by transmission line operators. Traditional management practices had focused entirely on maintaining a ROW, frequently devoid of vegetation, for the sole purpose of transmitting electricity in a reliable manner at the lowest level of operation and maintenance costs. More recently, operators are recognizing the benefits of managing ROW corridors to benefit natural resources. Key among these benefits are better compliance with laws to protect listed species and a reduction in negative public perception—the latter of which has resulted in lengthy delays and, at times, rejection of routes. Californians benefit from, and are positively responsive to, measures designed to minimize the environmental impacts of any development—and particularly to those that actually enhance the current conditions. In turn, transmission line developers benefit from a more positive reception from the community and regulators. California is in need of transmission system upgrades, including reconductoring and adding new lines, to meet near-term electricity demands. Therefore, it is critical to focus on research that addresses cost-effective technologies and tools that can help minimize the

environmental impacts and identify conservation opportunities of existing and future transmission line developments.

3.2 Pertinent Laws

A number of federal and state laws protect the species that are affected by transmission line ROWs. On a federal level, the Clean Water Act, the Endangered Species Act, the Migratory Bird Treaty Act, and others must be considered when siting and managing ROWs. On a state level, the California Environmental Quality Act and various Fish and Game Code sections must be addressed to protect plant and animal species.

On the electricity supply side, some recent California Senate bills regarding Integrated Energy Policy, a comprehensive renewable electricity generation resource plan, and the Renewable Portfolio Standard all act as drivers that spur the development of new transmission lines to meet the State's increasing electricity needs and the ability of new renewable generation units to supply power to the electricity grid.

Appendix A discusses these laws and bills in more detail.

3.3 The PIER Focus

California has a highly diverse series of ecological regions, each characterized by unique assemblages of plant and animal species, many of which are not found anywhere else (i.e., endemic species). On a national scale, California has the highest species diversity and highest number of endemic species of any state. California also ranks second in the proportion of species at risk and third in the number of species that are now extinct.[1] Population growth and associated land use changes and habitat degradation are increasingly threatening the health of the State's biodiversity, causing considerable concern by (and challenges to) the general public, regulators, and policy makers.

One function of the PIER Environmental Area is to address impacts to biological resources from power plant construction, operation, transmission, and use. Currently, there are about 40,000 miles of transmission lines in the State, and future energy demands will require system upgrades and new lines. Considering that transmission line ROWs are 150–300 feet wide, the area associated with transmission systems is somewhere between 0.75–1.5 million acres. Some of this area could be used to protect habitat and promote conservation while maintaining system reliability. Such environmentally responsible stewardship could help protect and restore sensitive areas or species at risk, contribute to more regional protection efforts, and may reduce public opposition to siting lines in urban areas. A better understanding of where development has the least amount of impact could reduce the time required for siting both upgrades and new developments.

The PIER Environmental Area will work with other PIER areas, other state agencies, and other stakeholders whenever feasible to leverage research funds, draw upon previous and ongoing efforts, and ensure the applicability of the research.

[1] See the NatureServe Web site at www.natureserve.org/conservation/usSpeciesatRisk.jsp.

4. Current Research and Research Needs

4.1 Current Status of Research Programs

This section outlines those efforts that most closely address the biological issues of siting and managing transmission line right-of-ways in California, both on a state and national level.

4.1.1 California

California Energy Commission

The California Energy Commission has several departments that address transmission line developing and planning. The Systems Assessment and Facilities Siting Division is charged with siting thermal power plants 50 megawatts or greater, including their associated transmission lines. The Commission's Renewable Energy Program provides market-based incentives for new and existing utility-scale facilities powered by renewable energy and considers new and existing transmission line load and location. Under PIER, three program areas are involved with research and development activities associated with the transmission system: Energy-Related Environmental Research (PIER-EA), Renewable Energy Technologies, and Energy Systems Integration. Recent and current transmission line-related research and development projects include:

- **Renewable Resource Development Report:** SB 1038 required the Energy Commission to develop a renewable resource plan and the California Public Utilities Commission to complete a transmission plan by December 2003. The PUC used the renewables report (CEC 2003a) to prepare the transmission plan (CPUC 2003). The renewable resources report describes the renewable resource potential available in the State, along with a plan to achieve the Renewable Portfolio Standard (SB 1078, as modified) target of increasing the annual amount of electricity generated from renewable sources to 20% of the total electricity for consumption in California by 2017. Paramount to this assessment is the need to review critically the State's operational compatibility of adding renewable generation sources to the existing system and the need to incorporate more transmission capacity to accommodate new renewable energy developments. Because the process of determining transmission line load demands, existing congestion, and viable renewable resource sites is complex, it is crucial to understand the State's transmission line needs, to successfully implement this plan.

- **Five-Year Transmission Research and Development Plan:** This plan (CEC 2003b) was developed by the Energy Systems Integration Program Area to guide and coordinate transmission research and development needs. One of two highest priority research initiatives is to "Refine and develop transmission expansion planning tools and approaches that can be used in a restructured utility industry to: assure transmission reliability is maintained in a cost effective manner; the environment is protected; avoid unnecessary duplication of facilities; reduce congestion; and provide for coordination with all parties involved in transmission line operation and use." To view the plan, go to: www.energy.ca.gov/reports/2003-11-25_500-03-104F.PDF.

- **Environmental-Related Research:** The Energy Commission had the Information Center for the Environment (ICE) at the University of California at Davis map and collate the acreage of rare habitats and species within two kilometer(s) of the existing power line corridors in the State (Appendix B). The Information Center for the Environment used the California Natural Diversity Database (CNDDB) for species occurrences and the California GAP analysis (Chung and Winer 1999), which incorporates the Holland (1986) vegetation classification system—a relatively coarse habitat classification. Examining these data sets on a regional basis can help identify areas of conservation concern and opportunity. PIER-EA is also sponsoring research on the effect of transmission line corridors on the demography of an endangered and highly endemic plant in Kern County, the Kern mallow. A goal of this project is to ensure that current and future transmission lines in this area do not contribute to the decline of the plant population or to the degradation of habitat for rare and endangered animals in the area.

Pacific Gas and Electric

Pacific Gas & Electric is conducting an informal investigation of impacts of various vegetation management techniques on listed plant species, noxious weeds, and habitat quality to help guide future management decisions regarding ROW clearing.

San Diego Gas and Electric

Unknown.

Southern California Edison

Southern California Edison (SCE) is investigating ways to manage their ROWs to benefit sensitive habitats and species. Projects include:

- A literature review of reports on beneficial uses of ROWs, particularly those describing measures used to enhance habitat for listed species.

- An investigation of means to determine how to value ecological assets and cost-effectively enhance those assets while keeping operation and maintenance costs down without adversely affecting reliability and safety.

- Developing a model, SITING 2003, to assess and compare economic, social, and environmental impacts associated with alternative transmission line routes.

The Western Area Power Administration

The Western Area Power Administration is implementing an Integrated Vegetation Management Program on its lines in California's Central Valley. The objective of the program is to control unwanted vegetation (including noxious weeds) that may hamper human safety and/or line reliability. This vegetation control will be conducted using any of several methods, including manual, mechanical, biological, or chemical means. The end result will be a stable, low-canopy landscape.

The State of California Resources Agency

The State of California Resources Agency has initiated The California Legacy Project to identify the means through which the State can pursue a comprehensive, strategic approach to preserving, restoring, and sustaining working landscapes, open space, and biological resources. The goals are to integrate conservation assessment and planning, and to provide a tool to aid decision makers in the processes of land use and

conservation implementation strategies. The methodology entails: (1) gathering and collating existing databases of information on biological resources, local land use planning, and drivers that may effect land use changes; (2) identifying data gaps, including data of poor resolution; and (3) dispersing this information through a series of models (e.g., watershed models) and Geographic Information System (GIS) maps at a scale adequate for preliminary stages of land use planning. More information on the Legacy Project can be found at www.legacy.ca.gov.

4.1.2 Regional and National

The Electric Power Research Institute (EPRI)

The Electric Power Research Institute (EPRI) has a national research program on Rights-of-Way Environmental Issues in Siting, Development, and Management. This program reviews methods for cost-effective vegetation management while addressing environmental and health concerns. The California Energy Commission is a member of this program. Current research projects under this program include:

- **Right-of-way Stewardship Bibliographic Database (2001):** This database contains 805 articles related to powerline corridor design, siting, construction, and management and includes articles on biodiversity, electromagnetic fields, edge effects, fragmentation, and invasive species.

- **Evaluation of the Risk to Human Health and the Environment from Methods to Control Vegetation:** A scoping study of the potential risks to human health and the environment from the use of herbicides and other methods in vegetation management.

- **Shrub Community Development:** Investigates the development of shrub communities along ROWs as a method to reduce vegetation maintenance costs while providing habitat for many species.

- **Quantification of ROW Ecological Impacts on Ecosystems for Existing Transmission Systems:** A compilation and assessment of available literature, case studies, methodologies, compensation practices, and identification of additional data needs for defining ROW-related potential ecological impacts and/or benefits related to endangered and exotic species, habitat fragmentation, and other issues.

- **Property Value Impact Study:** This project will use accepted real estate assessment practices and data on real estate sales to investigate values of property in proximity to a selected number of power line construction projects before, during, and after construction.

- **Eighth International Symposium on Environmental Concerns in Rights-of-Way Management:** This symposium, scheduled to take place in 2006, provides a forum for information exchange regarding research on environmental issues in ROW planning and management.

4.2 Research Needs

The research needs identified in this section are designed to fit a hierarchical and adaptive research model, and fall under one of four main themes: (1) risk assessment, (2) risk reduction, (3) compliance monitoring, and (4) technology transfer.

Risk assessment is needed to better identify conservation risk and opportunities. Risk reduction activities build on that knowledge and identify and addresses ROW management alternatives that will help achieve positive results. Compliance monitoring involves the development of tools and methods to facilitate environmental assessment of sites, and is needed to ensure that the steps taken actually result in the desired outcome. Technology transfer activities help identify means to disseminate information to all stakeholders and help those stakeholders ultimately make informed, scientifically valid decisions.

4.2.1 Identify Conservation Risk and Opportunities

Transmission line ROWs constitute millions of acres of habitat in the State, yet little is known about the ecological consequences of this ubiquitous feature of the landscape. Although occupation of land by ROWs may not seem to have an extraordinary impact, habitat loss in California from all types of development has been tremendous; therefore, the effect of individual projects contributes cumulatively to an overall loss of biodiversity in the State. All land management decisions are now a critical element in deciding how the remaining public resources will be protected or not. Therefore, developing a strategy that identifies opportunities to promote conservation within ROWs while maintaining system reliability could become an important contribution in statewide biodiversity planning efforts.

The effects of ROWs on biota are largely dependent on three factors: (1) the width of the ROW, (2) the species and habitat affected, and (3) the site-specific management practices. Potential negative impacts from ROWs include: habitat loss, fragmentation or degradation, soil erosion, and water pollution. Potential positive impacts include habitat refugia (that is, a refuge from the changing surrounding habitat) and facilitation of movement (e.g., nutrient and regional and local species migration). Understanding where these risks and opportunities exist will allow ROW managers to concentrate efforts to specific areas of need.

The Energy Commission developed maps and databases of rare species and habitats associated with the State's transmission line ROWs using the U.S. Geological Survey's Gap Analysis Program (GAP) analyses and Robert F. Holland's (1986) vegetation classification system. Holland's system is the best available; however, it is not at a level that is useful for a detailed environmental assessment. An alternative model of habitat classification is presented by Sawyer and Keeler-Wolf (Sawyer and Keeler-Wolf 1995), who have constructed a more detailed description of California communities. This treatment contains more than 200 habitat community designations that attempt to characterize the subtle but critical differences in vegetation across the State. In contrast, GAP analyses focus on vegetation types that are discernible through remote sensing (that is, information about an area is gathered without the researchers being physically in contact with the area), and hence identifies only a fraction of the habitat community types covered by Sawyer and Keeler-Wolf. Therefore, transmission lines may fall into sensitive areas that are discernable on a GAP map. Unfortunately, the Sawyer and

Keeler-Wolf study does not include a detailed map of the locations of habitat communities throughout the State.

EPRI's ROW Stewardship Bibliographic Database can be used to address ROW issues such as biodiversity, electromagnetic fields, edge effects, fragmentation, and invasive species. Also addressing this issue is EPRI's program to quantify ROW ecological impacts on ecosystems for existing transmission systems.

Pacific Gas & Electric is addressing this issue through its investigation of impacts of various vegetation management techniques on listed plant species, noxious weeds, and habitat quality.

Research Needs

1. Assess existing conditions within transmission line ROWs to evaluate potential conservation problems and opportunities. This effort will require analysis of the existing data from (for example) environmental impact reports, GIS surveys, aerial photography, the California Natural Diversity Database (CNDDB), published and unpublished literature searches, current conservation planning efforts (e.g., regional habitat conservation plans and listed species recovery plans), agricultural practices (including herbicide and pesticide use), and databases of exotic invasives.
2. Develop metrics for prioritizing high and low environmental risk situations and conservation opportunities. For example, highly invasive exotics, species specialists (i.e., species that are particularly dependent on a special set of habitat conditions), and unusually rare species would receive higher priority than situations without these attributes.
3. Develop a management strategy that identifies practices that can be undertaken in specific areas of the ROW to reduce risk to sensitive species and enhance conservation.

4.2.2 Identify and Assess ROW Management Alternatives

Management practices within a ROW affect the ecological structure and function of the natural community. System reliability and safety remain the primary concern, but in some instances these goals can be attained through management that least disrupts the cohesion of the surrounding environment. Past practices often focused only on achieving low operation and maintenance costs, and usually involved treatments of cutting, mowing, and herbicide use to keep the area devoid of tall-growing vegetation. More recently, transmission operators must abide by environmental regulations designed to protect water resources and listed species, reduce herbicide use in sensitive situations, and prevent further habitat loss and fragmentation. Additionally, public opposition to traditional management practices in neighborhoods adjacent to ROWs is increasing because of fears of the perceived effects of these practices on health, the environment, and visual and land values. As a result of this opposition, some operators have begun incorporating more environmentally friendly management practices such as IVM and other planting schemes that create a more gradual change in vegetative structure. The effects of these newer strategies on environmental function are not widely known, and therefore require diligent monitoring studies.

Information on the current practices used to manage California ROWs is not widely available to the public. Nationally, however, many IOUs are practicing and monitoring new management strategies designed to improve ecological integrity (Williams et al. 1997; Goodrich-Mahoney et al. 2002). Although lessons can be learned from these studies in other areas, California has a unique ecological structure, and state-specific studies will be required to deal with the vast diversity of situations present throughout the State; some management strategies that will work in the rainforest of the Northwest will not be applicable to the deserts in the Southwest, the Central Valley, the Southern Coastal Range, or the Sierra Range. However, to determine the effectiveness of various statewide management strategies, it will be necessary for stakeholders to identify and agree upon some common metrics and standardized methodologies.

Contributing to research in this area are Southern California Edison's literature review of reports on the beneficial uses of ROWs, and its work to value ecological assets and cost-effectively enhance those assets. EPRI is contributing with its investigations of the development of shrub communities along rights-of-way and its scoping study of the potential risks to human health and the environment from the use of herbicides and other vegetation management methods.

Research Needs

1. Assess current management and monitoring practices on transmission line ROWs in relation to their effects on habitat and sensitive species.
2. Develop standardized metrics and monitoring protocols for determining the effectiveness of management strategies.
3. Identify candidate sites for testing various management strategies to reduce invasive species, enhance sensitive resources, or provide other ecological benefits.
4. Conduct long-term monitoring to evaluate the success of the management strategies.

4.2.3 Develop Tools and Methods to Facilitate Environmental Assessment of Sites

The capacity margins of the existing transmission system are heavily burdened, and new lines and upgrades are necessary to keep pace with growing electricity needs. New lines will also be necessary to support new energy developments required to achieve the renewable portfolio standard. Past obstacles to building new lines have included environmental permitting processes and public opposition. Given the current and projected demand on the State's resources, new projects will receive greater environmental scrutiny and challenges. The ability to proactively identify, evaluate, and mitigate or avoid potential impacts would reduce the time and costs of environmental review.

Unfortunately, the tools necessary to conduct a comprehensive, proactive inventory are lacking. Although there are several disparate efforts to map land cover for California, there is no single data source that contains information for the entire state at a level of detail necessary to perform an adequate environmental review. Recognizing the need for improved land cover data in the State, The California Resources Agency's Legacy Project has been working with several state and federal agencies to collate existing, disjunct mapping efforts and increase the accuracy and resolution of the State's habitat mapping system. This interagency team has developed mapping standards and identified the essential natural resource attributes and data gaps necessary to provide a

single comprehensive data set that can meet the needs of all the agencies for the purposes of making proactive, informed decisions related to resource management and planning. The ultimate goal to provide maps at a scale of 1:24,000 will not replace the need for final ground surveys, but will allow for an early level of review and appraisal of biotic hot-spots, areas to avoid, and areas of potential conservation. Accomplishing this task for the 100 million acres of the State is a monumental fiscal and logistical challenge that will require incredible allocations of time and resources. As such, a completion date is likely long term. Nevertheless, this tool will provide a wide array of stakeholders with information that has been sorely lacking, yet vitally necessary for all future planning efforts.

As the GIS databases for the Legacy Project progress, the information can be overlain on maps of land areas being considered for new transmission line corridors. A series of weighted attributes can be compared over various route options for the purpose of prioritizing and eliminating routes early in the planning process. The weighted attributes should be transparent and agreed upon by state and federal agencies. Such a process could ultimately be organized into a resource risk prediction model that could facilitate a comparable and fair assessment of land areas throughout the State.

Southern California Edison's SITING 2003 model will assess and compare economic, social, and environmental impacts associated with alternative transmission line routes. SCE and PIER are collaborating on a potential program to complete this model.

Research Needs

1. Contribute to the research and development needs of the California Legacy Project, to facilitate earlier completion of the mapping efforts.
2. Develop a series of weighted attributes (e.g., degree of rarity, levels of species sensitivity, number of sensitive resources, contribution to existing land conservation efforts) that could be organized into a model that allows early prediction of associated risks to natural resources from transmission line ROW construction.

4.2.4 Identify Means to Disseminate Information

Information on ROW management issues and practices in the State is sorely lacking and generally not available to the public. Moreover, transmission line operators are not forthcoming about releasing that information. Such reluctance leads to a perception, whether real or not, that sensitive resources are not being properly managed in ROWs. Conversely, line operators often feel threatened with legal repercussions that could result from affecting protected species within the ROW during regular maintenance operations. It is in the interest of all stakeholders to develop a more open, cooperative atmosphere and exchange of information. The conservation community could benefit from incentives and legal provisions for feasible levels of take during management activities to ROWs that enhance habitat and dependent species. Line operators could benefit from adopting the best management strategies to protect resources—sharing success and failure stories, improving public perception of neighboring ROWs, and remaining in compliance with pertinent laws. In addition, due to California's overwhelming set of site-specific ecological conditions, and the correlating set of studies required to understand ROW management practices on the biota in the State, opportunities exist to support the academic community as it conducts and reports on needed research.

Recent technological advancements have increased the simplicity and efficiency of disseminating information. Web-based information sites are common, and widely used by national audiences. A Web site dedicated to ROW issues would provide instant access to important information such as regulatory policies and laws, research results and methodologies, and survey protocols.

Research Needs

1. Establish a cooperative working group—consisting of industry, regulators, and the scientific community—to develop a program that identifies means to coordinate research and disseminate information effectively. The group should investigate ways to protect line operators from legal repercussions when enhancing ROWs for sensitive resources. The group could also be charged with periodically updating this document to guide future research needs regarding ROW environmental issues.

5. Goals

The goal of PIER-EA research on the biological issues of siting and managing transmission line ROWs is to reduce and resolve impacts to biological diversity from habitat loss, fragmentation, and degradation from ROW management activities, and to facilitate environmental review of new line development or system upgrades while providing safe and reliable electricity to California consumers.

The achievement of those goals depends on the development of tools and methods that can be used to identify the biological and conservation risks and opportunities associated with ROW management, and to facilitate environmental assessments. Open dissemination of information will be key to a successful outcome.

This section outlines short- and long-term research objectives based on the information summary and synthesis presented in previous sections and discussions with utilities and regulators. *Short-term* refers to a 1–3 year time frame and *long-term* to 3–10 years.

The PIER-EA program recognizes that some work is currently under way in these areas and seeks to draw from, build upon, and broaden the focus of those efforts. Whenever possible, PIER-EA will identify existing efforts and form partnerships to leverage resources.

5.1 Short-term Objectives

5.1.1 Conservation Risk and Opportunities

A. Identify Conservation Risk and Opportunities ($500K)

Activities needed: (1) Using existing databases such as the Legacy Project, CNDDB, utilities information, land conservation planning efforts, and others, determine existing conditions within transmission line ROWs and identify potential conservation problems and opportunities. (2) Establish a group of regulators, industry biologists, academia, and resource experts to develop metrics for evaluating and prioritizing risk and management options. (3) Develop a statewide ROW conservation strategy.

Critical Factors for Success:

- Significant progress from the Legacy Project.
- Access to information from transmission line operators.
- Few data gaps on existing transmission lines.
- Consensus among agencies, utilities, academia, and researchers.

5.1.2 Right-of-Way Management Alternatives

A. Identify and Assess ROW Management Alternatives ($3M)

Activities needed: (1) Critically review existing management practices on ROWs in other areas and identify how they can be applied to ROWs in California. (2) Establish a team of utility, agency, and academic biologist representatives to develop standardized metrics, monitoring protocols, and desired management strategy outcomes, and identify the best candidate sites to implement these strategies. (3) Set up long-term monitoring studies to evaluate the success of these strategies.

Critical Factors for Success:

- Consensus among experts on establishing standardized protocols.
- Access to ROWs by utilities.

5.1.3 Environmental Assessment

A. Develop Tools and Methods to Facilitate Environmental Assessment of Sites ($3M)

Activities needed: (1) Work with the Legacy Project to identify mapping needs that will facilitate transmission line siting. (2) Establish a group of species and habitat experts to develop weighted conservation attributes of the State's natural resources. (3) Develop a model that can be used early in the planning process to predict areas of high conservation need and potential impact risk.

Critical Factors for Success:

- Leveraged funding and significant progress by the Legacy Project.
- Consensus among experts on the values of various conservation attributes.
- Agreement on model usefulness.

5.1.4 Information Dissemination

A. Identify Means to Disseminate Information ($500K)

Activities needed: (1) Establish a team of utility biologists, scientists, regulators, and experts in electronic information transfer to develop an effective method of information transfer and determine shared information needs. (2) Develop a conservation plan that establishes incentives for transmission line operators to protect listed and sensitive species while enabling implementation of necessary maintenance operations.

Critical Factors for Success:

- Leveraged funds and a host to develop and maintain electronic transfer of information.
- Legalities of Endangered Species Act, the California Environmental Quality Act (CEQA), and other laws.

Table 1. Short-term Budget

Objective	Projected Cost ($000)
5.1.1.A Identify Conservation Risk and Opportunities	500*
5.1.2.A Identify and Assess ROW Management Alternatives	3,000*
5.1.3.A Develop Tools and Methods to Facilitate Environmental Assessment of Sites	3,000*
5.1.4.A Identify a Means to Disseminate Information	500
Total Short-term Cost	**7,000**

Note: An asterisk (*) indicates a high probability that the work will be leveraged with other ongoing efforts. The figure given is the California Energy Commission's projected expenditure to complete the short-term work.

5.2 Long-term Objectives

5.2.1 Conservation Risk and Opportunities

A. Identify Conservation Risk and Opportunities

Activities needed: (1) Implement statewide conservation strategies. (2) Monitor progress and update strategies as more information is gathered.

5.2.2 Right-of-Way Management Alternatives

A. Identify and Assess ROW Management Alternatives

Activities needed: (1) Identify new alternative management schemes and continue to conduct monitoring studies to test the effectiveness of management practices.

5.2.3 Environmental Assessment

A. Develop Tools and Methods to Facilitate Environmental Assessment of Sites

Activities needed: (1) Continue supporting the development of fine resolution mapping of the State's sensitive resources. (2) Evaluate an assessment model's performance and usefulness to regulatory agencies and utilities. (3) Identify any upgrades necessary to enhance the model.

5.2.4 Information Dissemination

A. Identify Means to Disseminate Information

Activities needed: (1) Revisit and expand upon the conservation plan to facilitate conservation practices in ROWs, while providing land owners with information about laws regarding taking of listed species and potential exemptions with management practices provide benefits for these species. (2) Update electronic exchange venue as necessary. (3) Update this roadmap.

6. Leveraging R&D Investments

6.1 Methods of Leveraging

Much of the work identified in this roadmap would be collaborative with other entities; PIER-EA would either cofund projects by other entities, or use outside funds to support PIER-EA efforts. Specifically, this roadmap seeks to:

- provide PIER funds for cofunding existing or planned work by the Resource Agency, PG&E, SCE and other utilities; and

- solicit funds from utilities and municipalities to build upon their efforts, or to co-design new projects at the Energy Commission.

6.2 Opportunities

Co-sponsorship opportunities are likely with SCE, PG&E, and the Resources Agency. Each of these organizations is interested in addressing biological issues of siting and managing transmission line ROWs in California. The following specific collaborative opportunities have been identified:

- Develop a Siting Model with utilities
- Contribute to the Resources Agency Legacy Program

7. Areas Not Addressed by This Roadmap

The focus of this roadmap is on terrestrial biodiversity. This roadmap does not address avian collision with transmission conductors—a topic addressed in detail in another PIER-EA report titled, *A Roadmap for PIER Research on Avian Collisions with Power Lines in California* (500-02-072F). In addition, this roadmap does not address the impacts of Electromagnetic Fields on biological resources. That issue will be addressed in a separate report.

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Appendix A

Federal and State Laws That Apply to Transmission Line ROWs

This appendix outlines the major federal and state laws that apply to the siting and management of transmission line ROWs.

Federal Laws

Clean Water Act of 1977

Title 33, United States Code, section 404 et seq., prohibit the discharge of dredged or fill material into the waters of the United States without a permit.

Endangered Species Act of 1973

Title 16, United States Code, section 1531 et seq., and Title 50, Code of Federal Regulations, part 17.1 et seq., designate and provide for protection of threatened and endangered plant and animal species, and their critical habitat.

Migratory Bird Treaty Act

Title 16, United States Code, sections 703–712, prohibit the take of migratory birds, including their eggs.

Bald and Golden Eagle Protection Act

Title 16, United States Code, section 668, protects bald and golden eagles from possession, selling, purchase, barter, offers to sell, purchase or barter, transport, export or import, at any time or in any manner, alive or dead, or any part, nest, or egg thereof of the foregoing eagles.

Magnuson-Stevens Fishery Conservation and Management Act as Amended in 1996

Title 16 United States Code, section 1855(b), 50 CFR 600.905–930, define Essential Fish Habitat (EFH) for federally managed fish species as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." This law requires consultation by a federal agency with National Marine Fisheries Service when a proposed action may adversely affect EFH.

State Laws

California Environmental Quality Act (CEQA)

Public Resources Code section 21000 et seq. mandate protection of California's environment and natural resources to develop and maintain a high-quality environment now and in the future. Specific goals of CEQA are for California's public agencies to: (1) identify the significant environmental effects of their actions; and, either (2) avoid those significant environmental effects, where feasible; or (3) mitigate those significant environmental effects, where feasible.

Fish & Game Code Sections Protecting Biological Resources

California Endangered Species Act of 1984: Fish and Game Code section 2050 et seq. protect California's rare, threatened, and endangered species.

Nest or Eggs: Fish and Game Code section 3503 protects California's birds by making it unlawful to take, possess, or needlessly destroy the nest or eggs of any bird.

Birds of Prey or Eggs: Fish and Game Code section 3503.5 protects California's birds of prey and their eggs by making it unlawful to take, possess, or destroy any birds of prey or to take, possess, or destroy the nest or eggs of any such bird.

Migratory Birds: Fish and Game Code section 3513 protects California's migratory birds by making it unlawful to take or possess any migratory non-game bird as designated in the Migratory Bird Treaty Act or any part of such migratory non-game bird.

Fully Protected Species: Fish and Game Code sections 3511, 4700, 5050, and 5515 prohibit take of animals, or their habitat, that are classified as "Fully Protected" in California.

Non-game Birds: Fish and Game Code section 3800 et seq. protect all non-game birds by making it unlawful to take non-game birds or parts of a bird unless otherwise provided in this Code's section.

Significant Natural Areas: Fish and Game Code section 1930 et seq. designate certain areas such as refuges, natural sloughs, riparian areas, and vernal pools as significant wildlife habitat.

Native Plant Protection Act of 1977: Fish and Game Code section 1900 et seq. designates state rare, threatened, and endangered plants.

Streambed Alteration Agreement: Fish and Game Code section 1600, requires evaluation of project impacts to waterways, including impacts to vegetation and wildlife from sediment, diversions, and other disturbances.

California Code of Regulations – Endangered Species

Title 14, sections 670.2 and 670.5 list animals of California designated as rare, threatened, or endangered.

Regional Water Quality Control Board Certification

Federal Clean Water Act section 401 requires certifications from the state for discharge of dredge or fill material into Waters of the United States. The Regional Board provides certification after reviewing the U.S. Army Corp of Engineers permit.

Senate Bills Related to Transmission Line Planning

Senate Bill 1389 (Chapter 568, statutes of 2002; Bowen): Requires the Energy Commission to adopt a two-year Integrated Energy Policy, supported by three subordinate reports: the Electricity and Natural Gas Assessment; the Transportation Fuels, Technologies, and Infrastructure Assessment; and the Public Interest Energy Strategies (PIES) Assessment. Final drafts of these reports were published in October 2003.

Senate Bill 1038 (Chapter 505, statutes of 2002; Sher): Requires the Energy Commission to submit a comprehensive renewable electricity generation resource plan and the California Public Utilities Commission (PUC) to complete a transmission plan by December 1, 2003. The Renewable Resource Development Report (which was published in November 2003) describes the renewable resource potential in the state and a plan to achieve the Renewable

Portfolio Standard, and is a technical appendix to the PIES report. The PUC is directed to use the Renewable Resource Development Report to prepare the transmission plan.

Senate Bill 1078 (Chapter 515, statutes of 2002; Sher): Established the Renewable Portfolio Standard to increase the annual amount of electricity generated from renewable sources to equal 20 percent of the total electricity for consumption in California by 2017.

Appendix B

Vegetation Types within 2 Kilometers of Transmission Line Corridors

Natural communities with a high percentage of occurrence associated with a 2-km-wide corridor around existing transmission line right-of-way corridors. CNDDB stands for the California Natural Diversity Database.

Transmission line corridor:

Northern Hardpan Vernal Pool - 100%
Southern Willow Scrub - 74.5%
Northern Claypan Vernal Pool - 67.5%
Sandy Areas Other Than Beaches - 47%
Monterey Pine Forest - 46.6%
Mojave Desert Wash Scrub - 45.6%
Great Valley Valley Oak Riparian - 45%
Venturan Coastal Sage Scrub - 43%
Southern Arroyo Willow Riparian - 42%
Northern Maritime Chaparral - 40.7%

			2-km Corridor around Transmission Lines		
CNDDB	CNDDB NAME (Based on Holland 1986)	ACRES IN STATE	Acres (+- 10%)	% of State	% of Corridor
11200	Agricultural Land	7,358,645.03	2,653,187.21	36.1%	16.0%
45310*	Alkali Meadow	119,155.66	33,874.99	28.4%	0.2%
46000*	Alkali Playa	370,198.43	16,081.08	4.3%	0.1%
82310	Alluvial Redwood Forest	77,196.39	13,956.92	18.1%	0.1%
94000	Alpine Dwarf Scrub	156,201.83	149.53	0.1%	0.0%
71170	Alvord Oak Woodland	61,686.73	8,573.89	13.9%	0.1%
63820	Arrowweed Scrub	0.00	0.00		0.0%
81B00	Aspen Forest	18,806.60	0.00	0.0%	0.0%
61520*	Aspen Riparian Forest	2,297.21	0.00	0.0%	0.0%
11740	Bare Exposed Rock	1,409,214.95	22,418.30	1.6%	0.1%
11540	Bays and Estuaries	61,652.51	16,154.72	26.2%	0.1%
83110*	Beach Pine Forest	3,371.82	1,034.80	30.7%	0.0%
11720	Beaches and Coastal Dunes	18,546.55	2,700.78	14.6%	0.0%
35210	Big Sagebrush Scrub	853,550.82	49,137.40	5.8%	0.3%
84250*	Big Tree Forest	34,507.02	0.00	0.0%	0.0%

CNDDB	CNDDB NAME (Based on Holland 1986)	ACRES IN STATE	2-km Corridor around Transmission Lines		
			Acres (+- 10%)	% of State	% of Corridor
84150	Bigcone Spruce-Canyon Oak Forest	59,097.72	919.05	1.6%	0.0%
83120	Bishop Pine Forest	59,402.11	18,121.48	30.5%	0.1%
81340	Black Oak Forest	1,408,241.79	114,286.54	8.1%	0.7%
71120	Black Oak Woodland	424,853.99	47,137.69	11.1%	0.3%
35213	Black Sagebrush Scrub	0.00	0.00		0.0%
34300	Blackbush Scrub	303,715.20	42,426.39	14.0%	0.3%
37820	Blue Brush Chaparral	16,101.93	301.35	1.9%	0.0%
71140	Blue Oak Woodland	2,561,432.96	357,497.26	14.0%	2.2%
86400*	Bristlecone Pine Forest	22,710.29	205.04	0.9%	0.0%
37810	Buck Brush Chaparral	1,168,942.47	88,824.56	7.6%	0.5%
37550	Bush Chinquapin Chaparral	8,756.11	0.00	0.0%	0.0%
81200*	California Bay Forest	848.73	140.48	16.6%	0.0%
71210*	California Walnut Woodland	8,800.04	2,054.01	23.3%	0.0%
81320	Canyon Live Oak Forest	338,841.77	28,262.32	8.3%	0.2%
37830	Ceanothus crassifolius Chaparral	617,633.98	128,285.80	20.8%	0.8%
37840	Ceanothus megacarpus Chaparral	154,191.25	61,041.57	39.6%	0.4%
32200	Central (Lucian) Coastal Scrub	141,563.24	24,668.53	17.4%	0.1%
61230*	Central Coast Arroyo Willow Riparian Forest	5,717.04	682.56	11.9%	0.0%
61210*	Central Coast Cottonwood-Sycamore Riparian Forest	20,761.21	2,942.13	14.2%	0.0%
61220*	Central Coast Live Oak Riparian Forest	7,805.51	0.00	0.0%	0.0%
63200*	Central Coast Riparian Scrub	0.00	0.00		0.0%
21320	Central Dune Scrub	2,970.68	0.00	0.0%	0.0%
37C20*	Central Maritime Chaparral	53,402.76	4,851.66	9.1%	0.0%
35500	Cercocarpus ledifolius woodland	158,679.53	16,323.57	10.3%	0.1%
37200	Chamise Chaparral	1,391,194.57	205,751.56	14.8%	1.2%
52310*	Cismontane Alkali Marsh	4,165.34	0.00	0.0%	0.0%
72400	Cismontane Juniper Woodland and Scrub	8,112.62	0.00	0.0%	0.0%
81310	Coast Live Oak Forest	450,601.23	67,394.23	15.0%	0.4%
71160	Coast Live Oak Woodland	250,245.96	51,199.92	20.5%	0.3%
84110	Coast Range Mixed Coniferous Forest	3,600,844.77	143,055.83	4.0%	0.9%
84130	Coast Range Ponderosa Pine Forest	88,739.84	20,082.97	22.6%	0.1%
52410*	Coastal and Valley Freshwater Marsh	88,264.23	16,478.28	18.7%	0.1%
52200*	Coastal Brackish Marsh	66,713.49	8,845.65	13.3%	0.1%
82410*	Coastal Douglas Fir-Western Hemlock Forest	0.00	0.00		0.0%
41000	Coastal Prairie	204,792.92	61,186.81	29.9%	0.4%
37G00	Coastal Sage-Chaparral Scrub	70,903.97	24,647.63	34.8%	0.1%
84140	Coulter Pine Forest	94,323.02	5,011.58	5.3%	0.0%

			2-km Corridor around Transmission Lines		
CNDDB	CNDDB NAME	ACRES IN STATE	Acres	% of State	% of
	(Based on Holland 1986)		(+- 10%)		Corridor
11212	Deciduous Orchard	7,910.94	2,533.70	32.0%	0.0%
71182	Dense Engelmann Oak Woodland	50,112.97	8,167.08	16.3%	0.0%
62200*	Desert Dry Wash Woodland	867,794.25	128,835.12	14.8%	0.8%
22000	Desert Dunes	330,449.64	9,316.21	2.8%	0.1%
36130	Desert Greasewood Scrub	180,126.62	16,331.41	9.1%	0.1%
36150	Desert Holly Scrub	50,550.14	1,639.70	3.2%	0.0%
42160	Desert Native Grassland	54,375.76	3,801.71	7.0%	0.0%
36110	Desert Saltbrush Scrub	1,172,889.78	173,330.16	14.8%	1.0%
36120	Desert Sink Scrub	156,629.48	9,696.50	6.2%	0.1%
32600	Diablan Sage Scrub	193,627.93	14,971.59	7.7%	0.1%
32500*	Diegan Coastal Sage Scrub	315,747.34	120,780.80	38.3%	0.7%
11710	Dry Salt Flat	242,933.35	3,123.32	1.3%	0.0%
11204	Dryland Grain Crops	91,628.92	22,889.66	25.0%	0.1%
84220*	Eastside Ponderosa Pine Forest	1,831,106.22	196,168.83	10.7%	1.2%
11300	Eucalyptus	4,617.21	1,533.65	33.2%	0.0%
11211	Evergreen Orchard	7,658.02	5,051.84	66.0%	0.0%
71410	Foothill Pine-Oak Woodland	2,800,708.89	458,705.79	16.4%	2.8%
86300*	Foxtail Pine Forest	68,563.49	0.00	0.0%	0.0%
43000*	Great Basin Grassland	20,030.56	2,261.77	11.3%	0.0%
35100	Great Basin Mixed Scrub	1,731,575.15	105,361.87	6.1%	0.6%
45500	Great Basin Wet Meadow	48,997.95	1,630.02	3.3%	0.0%
72100	Great Basin Woodlands	2,363,778.74	131,255.17	5.6%	0.8%
61410*	Great Valley Cottonwood Riparian Forest	76,336.19	20,887.57	27.4%	0.1%
63420*	Great Valley Mesquite Scrub	5,877.30	2,270.97	38.6%	0.0%
61420*	Great Valley Mixed Riparian Forest	19,848.00	6,351.57	32.0%	0.0%
61430*	Great Valley Valley Oak Riparian Forest	13,161.54	5,922.27	45.0%	0.0%
63410*	Great Valley Willow Scrub	1,715.84	334.29	19.5%	0.0%
37542	Huckleberry Oak Chaparral	53,012.44	4,147.50	7.8%	0.0%
36320*	Interior Coast Range Saltbush Scrub	8,628.09	2,292.53	26.6%	0.0%
37A00	Interior Live Oak Chaparral	453,101.84	42,419.27	9.4%	0.3%
81330	Interior Live Oak Forest	733,481.39	105,364.91	14.4%	0.6%
71150	Interior Live Oak Woodland	310,788.57	69,149.28	22.2%	0.4%
11521	Intermittently-flooded Lacustrine Habitat	75,811.61	597.01	0.8%	0.0%
37D00*	Ione Chaparral	337.56	0.00	0.0%	0.0%
11203	Irrigated Grain Crops	31,266.83	934.37	3.0%	0.0%
11202	Irrigated Hayfield	703,973.65	96,795.16	13.7%	0.6%
85100	Jeffrey Pine Forest	724,297.27	27,268.49	3.8%	0.2%
85210	Jeffrey Pine-Fir Forest	1,113,098.47	15,315.64	1.4%	0.1%

			2-km Corridor around Transmission Lines		
CNDDB	CNDDB NAME	ACRES IN STATE	Acres	% of State	% of
	(Based on Holland 1986)		(+- 10%)		Corridor
73000	Joshua Tree Woodland	35,867.84	267.92	0.7%	0.0%
71430	Juniper-Oak Cismontane Woodland	114,547.61	18,895.68	16.5%	0.1%
91110	Klamath-Cascades Fell-Field	17,007.19	0.00	0.0%	0.0%
83210*	Knobcone Pine Forest	25,497.54	362.48	1.4%	0.0%
37620*	Leather Oak Chaparral	18,214.93	2,671.39	14.7%	0.0%
86700	Limber Pine Forest	843.73	0.00	0.0%	0.0%
86100	Lodgepole Pine Forest	673,582.24	3,911.44	0.6%	0.0%
35211	Low Sagebrush Scrub	372,170.27	26,361.18	7.1%	0.2%
83161*	Mendocino Pygmy Cypress Forest	3,688.33	861.65	23.4%	0.0%
37E00	Mesic North Slope Chaparral	136,292.98	9,381.65	6.9%	0.1%
61820*	Mesquite Bosque	12,382.92	934.37	7.5%	0.0%
11401	Mid-elevation Conifer Plantation	298,277.68	16,943.95	5.7%	0.1%
11770	Mixed Barren Land	103,728.24	207.66	0.2%	0.0%
81100	Mixed Evergreen Forest	1,068,095.47	154,740.97	14.5%	0.9%
37510	Mixed Montane Chaparral	337,779.70	13,547.28	4.0%	0.1%
71420	Mixed North Slope Cismontane Woodland	236,553.90	39,668.79	16.8%	0.2%
37610*	Mixed Serpentine Chaparral	70,930.82	2,705.82	3.8%	0.0%
84260	Modoc White Fir Forest	330,473.70	22,557.78	6.8%	0.1%
61610*	Modoc-Gr. Basin Cottonwood-Willow Riparian Forest	10,765.15	2,296.47	21.3%	0.0%
63600*	Modoc-Great Basin Riparian Scrub	8,791.37	743.75	8.5%	0.0%
34100	Mojave Creosote Bush Scrub	11,781,565.27	1,033,264.93	8.8%	6.2%
63700	Mojave Desert Wash Scrub	487.38	222.43	45.6%	0.0%
34220	Mojave Mixed Steppe	126,963.01	0.00	0.0%	0.0%
34240	Mojave Mixed Woody and Succulent Scrub	162,860.78	3,186.49	2.0%	0.0%
34210	Mojave Mixed Woody Scrub	2,501,379.43	147,709.98	5.9%	0.9%
61700	Mojave Riparian Forest	7,854.39	1,562.14	19.9%	0.0%
72200	Mojavean Pinyon and Juniper Woodlands	1,060,846.76	63,012.62	5.9%	0.4%
61530*	Montane Black Cottonwood Riparian Forest	2,782.61	190.91	6.9%	0.0%
37530	Montane Ceanothus Chaparral	190,700.21	24,552.99	12.9%	0.1%
37520	Montane Manzanita Chaparral	219,384.66	24,420.29	11.1%	0.1%
45100	Montane Meadow	57,910.99	3,261.02	5.6%	0.0%
63500*	Montane Riparian Scrub	13,170.59	440.40	3.3%	0.0%
83130*	Monterey Pine Forest	12,307.50	5,734.60	46.6%	0.0%
23300*	Monvero Residual Dunes	750.10	0.00	0.0%	0.0%
11780	Mud Flats	10,521.19	6.76	0.1%	0.0%
63310	Mule Fat Scrub	24,469.43	8,291.09	33.9%	0.1%
99999	No secondary or tertiary type	0.00	0.00		0.0%
42200	Non-Native Grassland	6,805,839.48	1,724,817.86	25.3%	10.4%

CNDDB	CNDDB NAME (Based on Holland 1986)	ACRES IN STATE	2-km Corridor around Transmission Lines Acres (+- 10%)	% of State	% of Corridor
71322	Non-Serpentine Foothill Pine Woodland	142,024.71	14,984.97	10.6%	0.1%
61110*	North Coast Black Cottonwood Riparian Forest	0.00	0.00		0.0%
63100*	North Coast Riparian Scrub	2,920.33	0.00	0.0%	0.0%
32100	Northern (Franciscan) Coastal Scrub	105,039.28	14,144.92	13.5%	0.1%
44131*	Northern Basalt Flow Vernal Pool	686.17	187.07	27.3%	0.0%
44120*	Northern Claypan Vernal Pool	391.84	264.59	67.5%	0.0%
31100*	Northern Coastal Bluff Scrub	17,666.70	0.00	0.0%	0.0%
52110	Northern Coastal Salt Marsh	11,666.69	3,671.16	31.5%	0.0%
21310	Northern Dune Scrub	30,973.02	3,101.47	10.0%	0.0%
21210	Northern Foredunes	0.00	0.00		0.0%
44110*	Northern Hardpan Vernal Pool	13.00	12.99	100.0%	0.0%
83220*	Northern Interior Cypress Forest	43,776.16	58.25	0.1%	0.0%
37C10*	Northern Maritime Chaparral	679.78	276.64	40.7%	0.0%
37110	Northern Mixed Chaparral	427,307.84	96,840.82	22.7%	0.6%
84171	Northern Ultramafic Jeffrey Pine Forest	86,997.55	4,125.39	4.7%	0.0%
71600	Oak-Pinyon Woodland	43,358.92	0.00	0.0%	0.0%
71310	Open Foothill Pine Woodland	352,638.10	95,902.99	27.2%	0.6%
11210	Orchard or Vineyard	1,552,938.17	601,425.42	38.7%	3.6%
71110	Oregon Oak Woodland	591,784.51	69,362.40	11.7%	0.4%
11206	Pasture	143,093.89	60,653.44	42.4%	0.4%
47000*	Pavement Plain	0.00	0.00		0.0%
72300	Peninsular Pinyon and Juniper Woodlands	82,866.32	8,246.35	10.0%	0.0%
11520	Permanently-flooded Lacustrine Habitat	1,001,676.39	74,166.65	7.4%	0.4%
82500*	Port Orford Cedar Forest	0.00	0.00		0.0%
35400	Rabbitbrush Scrub	27,075.66	684.62	2.5%	0.0%
61130*	Red Alder Riparian Forest	2,606.94	204.13	7.8%	0.0%
85120	Red Fir (Lodgepole Pine)-Western White Pine Forest	338,541.56	3,008.70	0.9%	0.0%
85310	Red Fir Forest	1,265,010.11	20,840.88	1.6%	0.1%
37300	Red Shank Chaparral	279,158.94	9,312.24	3.3%	0.1%
11205	Rice Fields	0.00	0.00		0.0%
32700*	Riversidian Sage Scrub	154,902.19	44,618.09	28.8%	0.3%
11201	Row and Field Crops	2,741,637.40	994,670.43	36.3%	6.0%
85420*	Salmon-Scott Enriched Coniferous Forest	279,524.21	0.00	0.0%	0.0%
35110	Salvia dorri/Chamaebatiaria scrub	5,605.37	0.00	0.0%	0.0%
11730	Sandy Area Other than Beaches	38,618.43	18,137.81	47.0%	0.1%
84120*	Santa Lucia Fir Forest	4,388.83	0.00	0.0%	0.0%
37900	Scrub Oak Chaparral	444,675.89	35,850.08	8.1%	0.2%

			2-km Corridor around Transmission Lines		
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37400	Semi-Desert Chaparral	534,139.02	47,563.83	8.9%	0.3%
71321	Serpentine Foothill Pine-Chaparral Woodland	129,808.91	6,699.81	5.2%	0.0%
36140	Shadscale Scrub	739,815.14	65,634.78	8.9%	0.4%
37541	Shin Oak Brush	14,162.08	2,144.13	15.1%	0.0%
91120	Sierra Nevada Fell-Field	16,618.30	0.00	0.0%	0.0%
84230	Sierran Mixed Coniferous Forest	4,304,492.43	339,831.24	7.9%	2.0%
84240	Sierran White Fir Forest	209,820.75	14,259.27	6.8%	0.1%
35212	Silver Sagebrush Scrub	19,924.77	0.00	0.0%	0.0%
85410*	Siskiyou Enriched Coniferous Forest	61,038.20	0.00	0.0%	0.0%
82100	Sitka Spruce-Grand Fir Forest	87,046.85	29,958.78	34.4%	0.2%
61810*	Sonoran Cottonwood-Willow Riparian Forest	0.00	0.00		0.0%
33100	Sonoran Creosote Bush Scrub	3,452,369.00	479,413.48	13.9%	2.9%
33200	Sonoran Desert Mixed Scrub	1,532,574.56	147,949.09	9.7%	0.9%
63330	Southern Alluvial Fan Scrub	5,064.11	69.18	1.4%	0.0%
61320*	Southern Arroyo Willow Riparian Forest	4,658.43	1,955.00	42.0%	0.0%
86500	Southern California Subalpine Forest	17,008.41	0.00	0.0%	0.0%
85320	Southern California White Fir Forest	3,676.22	0.00	0.0%	0.0%
61310*	Southern Coast Live Oak Riparian Forest	3,715.69	141.36	3.8%	0.0%
31200*	Southern Coastal Bluff Scrub	8,191.22	990.80	12.1%	0.0%
52120*	Southern Coastal Salt Marsh	3,099.22	1,150.20	37.1%	0.0%
61330*	Southern Cottonwood-Willow Riparian Forest	14,702.99	2,410.84	16.4%	0.0%
83330*	Southern Interior Cypress Forest	522.83	0.00	0.0%	0.0%
37120	Southern Mixed Chaparral	50,493.50	16,225.55	32.1%	0.1%
62400*	Southern Sycamore-Alder Riparian Woodland	2,000.37	8.00	0.4%	0.0%
63320*	Southern Willow Scrub	539.07	401.80	74.5%	0.0%
51110*	Sphagnum Bog	267.80	0.00	0.0%	0.0%
11510	Streams and Canals	71,329.74	14,759.21	20.7%	0.1%
11750	Strip Mines, Quarries and Gravel Pits	50,255.28	16,463.94	32.8%	0.1%
45200	Subalpine or Alpine Meadow	47,120.27	5,652.44	12.0%	0.0%
35220	Subalpine Sagebrush Scrub	28,668.30	0.00	0.0%	0.0%
62100*	Sycamore Alluvial Woodland	2,267.91	0.00	0.0%	0.0%
63810	Tamarisk Scrub	37,599.50	15,019.59	39.9%	0.1%
81400	Tan-Oak Forest	519,253.79	43,561.27	8.4%	0.3%
11760	Transitional Bare Areas	34,842.75	11,978.09	34.4%	0.1%
52320*	Transmontane Alkali Marsh	6,129.19	335.75	5.5%	0.0%
52420*	Transmontane Freshwater Marsh	62,844.44	5,009.65	8.0%	0.0%
84180	Ultramafic Mixed Coniferous Forest	63,767.02	4,614.05	7.2%	0.0%
84160	Ultramafic White Pine Forest	0.00	0.00		0.0%

			2-km Corridor around Transmission Lines		
CNDDB	CNDDB NAME	ACRES IN STATE	Acres	% of State	% of
	(Based on Holland 1986)		(+- 10%)		Corridor
82420*	Upland Douglas-Fir Forest	62,731.69	5,078.88	8.1%	0.0%
82320	Upland Redwood Forest	1,425,818.74	158,407.67	11.1%	1.0%
37B00	Upper Sonoran Manzanita Chaparral	199,701.44	30,708.69	15.4%	0.2%
39000	Upper Sonoran Subshrub Scrub	91,786.55	6,880.13	7.5%	0.0%
11402	Upper-elevation Conifer Plantation	17,871.08	0.00	0.0%	0.0%
11100	Urban or Built-up Land	4,512,008.75	2,629,871.20	58.3%	15.9%
42110*	Valley Needlegrass Grassland	2,290.53	668.32	29.2%	0.0%
71130	Valley Oak Woodland	179,275.91	36,554.62	20.4%	0.2%
42120*	Valley Sacaton Grassland	2,255.50	0.00	0.0%	0.0%
36220*	Valley Saltbush Scrub	456,172.60	160,020.40	35.1%	1.0%
36210*	Valley Sink Scrub	47,493.84	15,097.12	31.8%	0.1%
32300	Venturan Coastal Sage Scrub	488,352.94	210,385.75	43.1%	1.3%
11213	Vineyard	338,595.27	153,162.83	45.2%	0.9%
84210	Westside Ponderosa Pine Forest	2,335,221.81	183,606.51	7.9%	1.1%
61510*	White Alder Riparian Forest	5,258.59	446.08	8.5%	0.0%
86600	Whitebark Pine Forest	39,491.32	944.82	2.4%	0.0%
86220	Whitebark Pine-Lodgepole Pine Forest	175,134.34	2,420.59	1.4%	0.0%
86210	Whitebark Pine-Mountain Hemlock Forest	80,281.44	94.45	0.1%	0.0%
42300*	Wildflower Field	2,587.87	586.98	22.7%	0.0%
	TOTAL	101,002,642.33	16,578,956.13	ACRES	

* Considered rare

A description of the vegetation classes and the methodology used to collect the data for the state is found at: http://www.biogeog.ucsb.edu/projects/gap/gap_rep.html.